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Memo

DATE: *June 2, 2006*

TO: RHIC E-Coolers

FROM: *Ady Hershcovitch*

SUBJECT: **Minutes of the June 2, 2006 Meeting**

Present: Ilan Ben-Zvi, Andrew Burrill, Xiangyun Chang, Wolfram Fischer, Harald Hahn, Ady Hershcovitch, Dmitry Kayran, Jorg Kewisch, Vladimir Litvinenko, Derek Lowenstein, Thomas Roser, Dejan Trbojevic, Gang Wang.

Topics discussed: Calculations and Simulations, Diamond Cathode

Although neither the RHIC electron beam cooling Collaboration Workshop, nor the recent very significant Stochastic Cooling results obtained in the RHIC yellow ring were discussed in this meeting, these topics will be covered in the present minutes.

Collaboration Workshop: as a follow up on recommendations resulting from the last Machine Advisory Committee Meeting, a 3-day collaboration workshop took place at BNL during May 24-26, 2006. The workshop covered two subjects that are important to electron cooling of RHIC: First, the theory, simulations and benchmarking of classical (non-magnetized) electron cooling at high energy; second, the physics and technology for generating high-charge, low emittance electron beams from a superconducting RF laser-photocathode electron gun. Plenary sessions and two working groups covered intensely the subject. The meeting, which was by invitation only, assembled leading experts from around the world and the country, concluded that there are no show-stoppers to the plans which was presented by members of the RHIC Electron Cooling group towards cooling of RHIC.

In its summary, the photoinjector working group suggested studying of various laser issues, especially pulse shaping. The group noted the importance of developing the diamond cathode, as it would greatly alleviate photon budget issues. A number of beam dynamic issues were also addressed. The PARMELA code is adequate except for bends, and the group suggested studying beam dynamics in bends with other codes as well. It also suggested pushing codes like VORPAL especially for 3D problems and further study near cathode dynamics, various space charge contributions, etc. The electron beam cooling workgroup examined the various cooling models and experiments. It also examined stability issues; the models are adequate, and the RHIC electron beam cooler is orders of magnitude below two-beam instability thresholds. The workgroup concluded that current status of cooling studies is very rigorous and encouraging. Both working groups made recommendations for future R&D subjects.

More details about the meeting as well as the meeting agenda that includes all presentations can be found at http://www.bnl.gov/cad/ecooling/Meetings/May_24_2006/agenda.asp

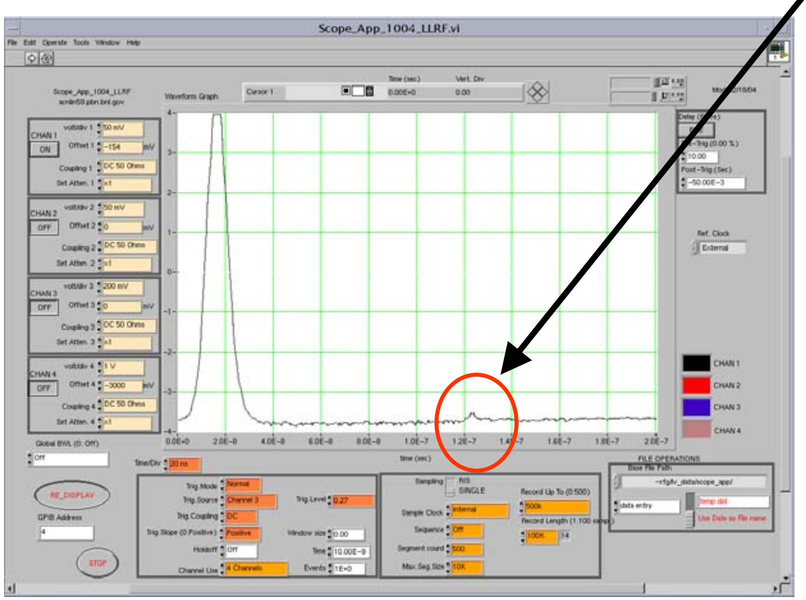
Stochastic Cooling: Two days ago, Mike Blaskiewicz and Mike Brennan reported successful stochastic cooling that was achieved in the RHIC yellow ring. They were able to cool a test bunch of protons in about one hour. A big challenge was to actually trace the test bunch containing $2x10^9$ protons among the 100 bunches each containing about $1.5x10^{11}$ protons (to cool $1.5x10^{11}$ protons would have required 100 hours). Recall, our kicker is comprised of 16 cavities, with 10 MHz bandwidths, spaced at 200 MHz intervals in the band 5 to 8 GHz. We have 2/3 of a turn delay from pickup to kicker as the signal from the pickup comes to the low level electronics and the kickers via fiber optics over a distance of 1/3 of a turn against the direction of the beam.

In this paragraph and the attached presentation below Mike & Mike describe their experiment. The first slide shows our bunch next to a normal bunch seen on the wall current monitor. The bunch spacing is 106 ns, and we are midway between two normal bunches. The second slide is our bunch only, shown before and after cooling it for 90 minutes. The bunch clearly gets shorter and we don't lose any particles, as the integral of the curve confirms. The third slide is Schottky spectra at 4 GHz. We measure at 4 GHz even though our systems works only from 5 to 8 GHz to show that this scheme of isolated kickers does really affect the full spectrum of the beam. The first frame shows signal suppression, loop open compared to closed loop. We're not pushing the gain. The other frames show how the spectrum changes as the cooling progresses. We switch off the cooling to take these spectra.

Calculations and Simulations: during the meeting Jorg described electron beam simulations, from cathode to gun exit, he has performed. Simulations were done with both PARMELA and ImpactT codes. There is till inconsistency between the codes, which Jorg is trying to reconcile. The status is the following: PARMELA predicts a larger beam envelope; but increasing the charge by 18% in the ImpactT code yields the same beam envelope. Transverse phase space is characterized by "hooks" in both codes. However, in PARMELA only lead slice displays the hook, while in ImpactT only the mid-slice has a hook. A discussion ensued regarding which code is more correct.

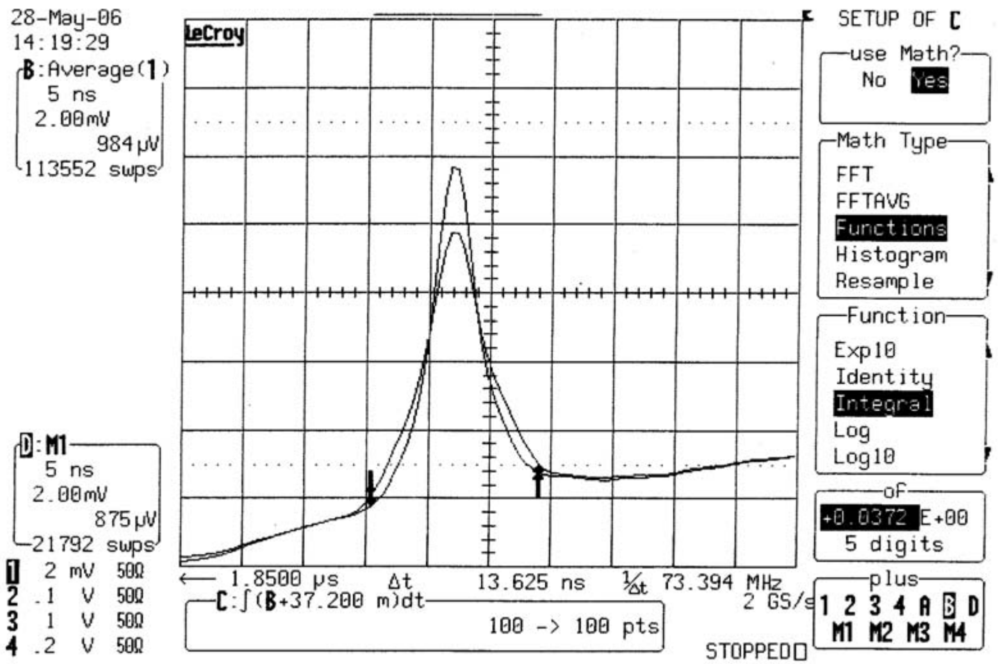
Diamond Cathode: the meeting concluded with Xiangyun showing the latest results with a 150-micron thick electronic grade diamond cathode (previous results were with 450-micron thick diamond). This sample was also prepared differently especially in the application of the metal coating. The results were that the gain (factor increase in current over the primary electron beam) was about 65, **but at much lower electric fields**. Xiangyun also showed emission results at cryogenic temperature (80 K) for the first time.

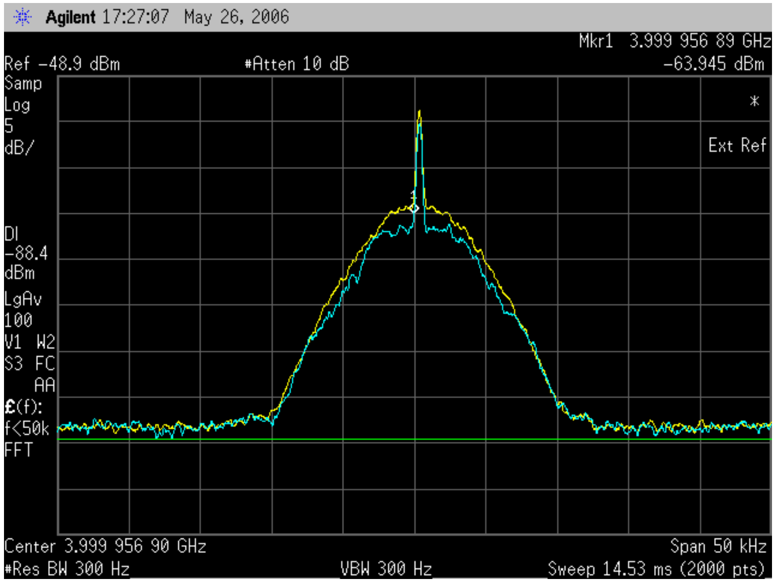
Low-Intensity Test Bunch



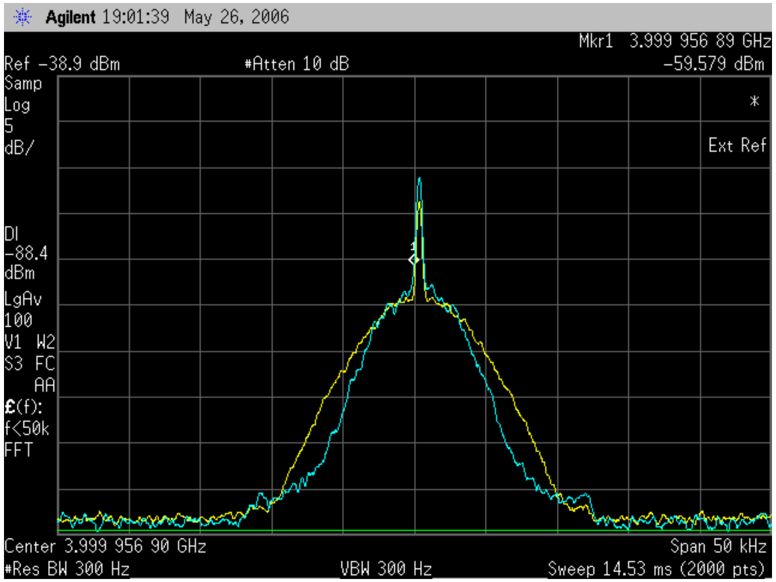
- The bunch we used for cooling tests was ~2e9 protons. Normal bunch is 1.5e11.

Wall Current Monitor signal of cooled bunch. The higher bunch has been cooled for about 90 minutes. The lower trace is the bunch before cooling started.

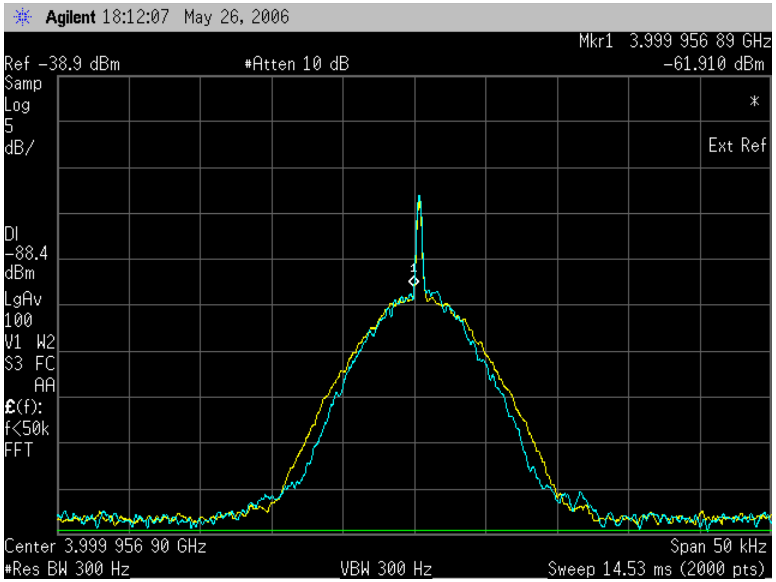


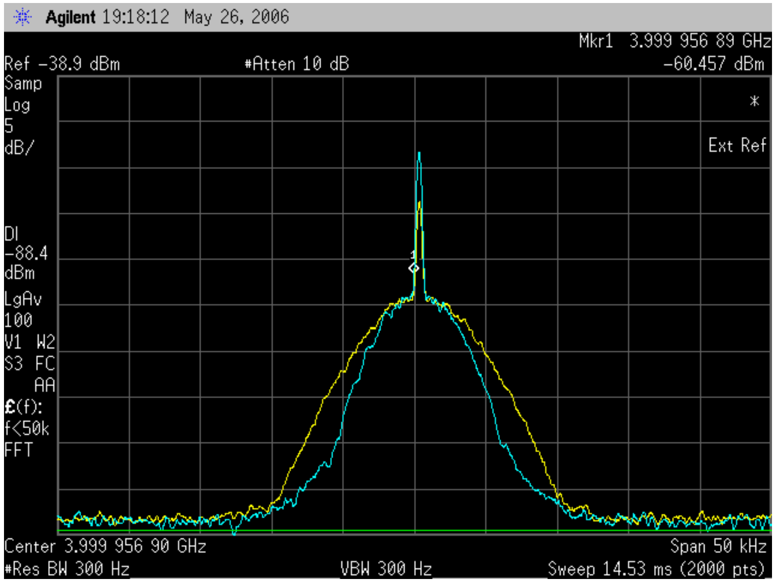


Yellow: reference, Blue: Signal suppression



Yellow: reference Blue: 90 minutes cooling





Yellow: reference, Blue: 40 minutes cooling

Yellow: reference, Blue: 110 minutes cooling